Engineering Graphics

• Presentation graphics
• Levels of hardware visualization
  - Sketching
  - Drawing
  - Drafting
  - Solid modeling
• Visual presentation of data
Presentation Graphics

• Always use landscape, not portrait layout
  - Better fit to screens and projectors
  - Follows natural eye motions
  - Not much choice with computer projections, anyway

• When printed as 8.5”x11”, all features should be readable when laid on the ground at your feet

• All the data goes on the viewgraph - presentations live on after the talk!

• Maximize information density while maintaining legibility, audience comprehension
Choosing a Background Format

- Unifying graphical element throughout the presentation
- Especially important for a multi-person team presentation

Some critical issues to think about:
- Do the graphics add or detract from the focus of the presentation?
- How do they look printed out in B&W?
- How will be look when projected in each possible format (computer, viewgraphs, etc.)?
Slide Layout

- Easy-to-read text
- Adaptable to multiple elements (text, figures, pictures, etc.)

Who’s responsible for this product?

What is this presentation?

What does this fit into?
Another Example of Slide Layout

Subtle reminder of what the project is all about

What is the project or program?

Unobtrusive graphical element for visual interest

Graphical icon for organization

Who’s responsible for this product?

Space Systems Laboratory – University of Maryland
Presentation Pitfalls

- Don’t OVERDO The Use Of Capital Letters - And At least Be consistent!
- Proofreed! Chek teh grammer and speling!
- Jest besides you’re spell-checker don’t flag some ding didn’t mean thee slid is all write!
- Resist the urge to play games with lots of multiple fonts and colors and sounds and sizes
- Don’t read the viewgraphs to the audience
- Don’t face the screen when you talk

The audience’s attention should be focused on what you’re saying, not how you’re presenting it!
Low Information Density

- Some say just six lines
- Only six words on each line
- They're totally wrong!
What are the Unknowns in Space Robotics?
(An example of ineffective information transfer)

- Can we count on dexterous robotics to work when planning future missions? What are their capabilities and limitations? Can we build a useful robot for a reasonable amount of money?
- Can we teleoperate in orbit from the ground? What are the performance hits due to time delays? Can advanced control station technologies ameliorate these hits?
- Can a robot be designed to use interfaces other than ones specifically designed for robots? Can robots adapt to EVA interfaces, reducing (or eliminating!) the design overhead for robotic servicing?
- How does increasing the capabilities of a robot through greater numbers of manipulators affect system performance? How can we increase degrees of freedom without proportional increases in operator workload?
- Are interchangeable end effectors a viable approach to increasing dexterity without increasing degrees of freedom? Can we perform EVA tasks without EVA dexterity?
- How does robotic performance change in the presence of realistic (i.e., not perfectly rigid) attachment to the work site? Can robot repositioning capability add to system performance?
What are the Unknowns in Space Robotics?

- Ground Control?
- Capabilities and Limitations?
- Multi-arm Control and Operations?
- Flexible Connections to Work Site?
- Robotic Use of EVA Interfaces?
- Effects and Mitigation of Time Delays?
- Control Station Design?
- Human Workload Issues?
- Utility of Interchangeable End Effectors?
- Manipulator Design?
- Hazard Detection and Avoidance?
- Development, Production, and Operating Costs?
- Ground-based Simulation Technologies?
Sketching

- Pencil-and-paper or simple drawing programs
- Quick representation of concepts
- Invaluable for ensuring that all team members share a common concept
- Talent helps - but lack of it isn’t an excuse for skipping the sketch
Sketching to Effectively Communicate

Figure 2-4. Delta IV Heavy Sequence of Events for a GTO Mission (Eastern Range)

From Boeing Corporation, Delta IV Payload Planners Guide, 1999

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Altitude (km)</th>
<th>Acceleration (g)</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1.21</td>
<td>Liftoff</td>
</tr>
<tr>
<td>59</td>
<td>3.5</td>
<td>1.47</td>
<td>Start core throttle-down</td>
</tr>
<tr>
<td>59</td>
<td>4.5</td>
<td>1.28</td>
<td>Core throttle at 60%</td>
</tr>
<tr>
<td>69</td>
<td>11.1</td>
<td>1.44</td>
<td>Mach number = 1.0</td>
</tr>
<tr>
<td>69</td>
<td>11.3</td>
<td>1.44</td>
<td>Maximum dynamic pressure</td>
</tr>
<tr>
<td>238</td>
<td>69</td>
<td>4.20</td>
<td>Start strap-ons throttle-down</td>
</tr>
<tr>
<td>244</td>
<td>72</td>
<td>3.01</td>
<td>Strap-ons throttle at 60%</td>
</tr>
<tr>
<td>249</td>
<td>74</td>
<td>3.13</td>
<td>Two strap-ons cutoff</td>
</tr>
<tr>
<td>249</td>
<td>74</td>
<td>1.04</td>
<td>Start core throttle-up</td>
</tr>
<tr>
<td>251</td>
<td>75</td>
<td>1.79</td>
<td>Jettison two strap-ons</td>
</tr>
<tr>
<td>254</td>
<td>77</td>
<td>2.50</td>
<td>Core throttle at 100%</td>
</tr>
<tr>
<td>327</td>
<td>116</td>
<td>4.40</td>
<td>Main-engine cutoff (MECO)</td>
</tr>
<tr>
<td>332</td>
<td>119</td>
<td>0.00</td>
<td>Stage III separation</td>
</tr>
<tr>
<td>349</td>
<td>129</td>
<td>0.23</td>
<td>Stage II ignition</td>
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<tr>
<td>358</td>
<td>134</td>
<td>0.25</td>
<td>Jettison fairing</td>
</tr>
<tr>
<td>383</td>
<td>198</td>
<td>0.35</td>
<td>Second-stage engine cutoff 1 (SECO-1)</td>
</tr>
<tr>
<td>3872</td>
<td>152</td>
<td>0.35</td>
<td>Stage II ignition 2</td>
</tr>
<tr>
<td>4431</td>
<td>401</td>
<td>0.61</td>
<td>Second-stage engine cutoff 2 (SECO-2)</td>
</tr>
</tbody>
</table>


Drawing

- Formal adherence to dimensions, spatial relationships
- Typically done on specialized drawing or 2D drafting packages (or manually)
- More time-consuming than sketching; arguably faster than solids modeling
- Line drawing typically well suited to publication
Technical Drawing (Three-View) Example

All dimensions in meters
Drafting

• Highly formalized representation of all details of component
• 2D representation of 3D objects through multiple views
• Required mastery of sophisticated software package(s)
• Not generally appropriate for preliminary design activities
Solid Models

- Allows 3D design, provides most realistic rendering, allows virtual manipulation for comprehension
- Takes the place of several older skills:
  - Technical illustrator
  - Graphic artist
  - Model-maker
Numerical Precision and Units

- Precision: every digit you use says that you know the parameter to that level of accuracy
  - “1 mile” - accurate to ~ 1/2 mile (~800 m)
  - “1.609344 km” - accurate to .0005 m

- Precision is only associated with trailing zeros after the decimal point
  - 13,400; 134; 1.34; .000134 all to 3 places
  - 1.34000 is 6 places of precision

- Only nondimensional parameters should ever appear without units attached
Visual Presentation of Information

The classics in this field are by Edward R. Tufte of Yale University

- The Visual Display of Quantitative Information
- Envisioning Information
- Visual Explanations
- Visual and Statistical Thinking: Displays of Evidence for Making Decisions

All from Graphics Press
Basic Concepts

• The primary responsibility is to the data
  - Don’t falsify it
  - Don’t withhold it
  - Don’t obscure it
  - Don’t decorate it
• Maximize the data-ink ratio
• Eliminate chartjunk
• Maintain graphical integrity
Misrepresentation of Data

- Chart only represents one piece of data (30°)
- Extra chartjunk (lines, shading, symbols) obscure information content
Misuse of Plotting Features

- Smoothing function without data markers implies continuity that doesn’t exist
- Show actual data with markers - use line only for analytical curve fit
More Bad Plotting Ideas
Why Pie Charts Suck

- Absolute data is eliminated in favor of relative comparisons
- Extremely low data-ink ratio
The “Best Graphic Ever Made”

The “Worst Graphic Ever Made”

The Slide That Was Presented

O-ring damage index, each launch

26°–29° range of forecasted temperatures (as of January 27, 1986) for the launch of space shuttle Challenger on January 28

Temperature (°F) of field joints at time of launch

Akin's Laws of Spacecraft Design - #20

A bad design with a good presentation is doomed eventually. A good design with a bad presentation is doomed immediately.